Enabling water footprint assessment in apparel manufacturing facilities:

A case of Sri Lanka

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Abstract

Achieving sustainability in the industrial sector is now a global concern. In sustainable development, water sustainability is considered as a high priority area in the face of threats posed to freshwater resources. Water footprint of an industry is a measurement of the total amount of water consumed by it throughout its supply chain and/or the amount of water polluted by its effluents. However, the concept of water footprint is still new and most of the industries do not have a streamlined procedure in place to follow when carrying out water footprint assessments. The current practices related to water footprint assessments were therefore evaluated with special emphasis on the apparel manufacturing industry, with a view to identifying the key enablers of and barriers to water footprint assessment and the approaches suitable to overcome the barriers so identified. Case study approach was used in this research because of the requirement for an in-depth investigation. Three apparel manufacturing facilities in Sri Lanka were studied by conducting semi-structured interviews with industry practitioners who had been involved in water footprint assessment procedure in each institution. Qualitative data that were gathered were evaluated using cross case analysis to identify the key enablers of and barriers to the existing water footprint assessment practices under five key headings, namely general awareness; setting goals and scope; water footprint accounting; water footprint sustainability assessment; and water footprint response formulation. A framework giving solutions is proposed finally to assist the proper implementation of water footprint assessment in the apparel manufacturing industry in Sri Lanka.

Keywords: Apparel manufacturing industry, Barriers, Enablers, Sri Lanka, Water footprint assessment

1. Introduction

By designing built facilities sustainably their impact on the environment can be reduced considerably. Water sustainability receives high priority in sustainable designs (Sodhi and Yatskovskaya, 2014). Of all the water on earth, 97.5% is salt water and only the remaining 2.5% is available as freshwater to meet the day to day needs of the humans. 68.9% of freshwater available on earth is contained in glaciers, 30.8% is available as groundwater which includes soil moisture as well, and only 0.3% is available in lakes and rivers (Diop, M'mayi and Lisbjerg, 2002). Fresh water resources around the globe are rapidly diminishing and therefore there is a need to reduce water usage (World Water Assessment Programme - WWAP, 2015). Water usage is currently measured based on the amount of water withdrawn from water resources (Ridoutt, Eady, Sellaheewa, Simons and Bektash, 2009). With the growth of population, introduction of new energy and food security policies, and urbanisation, the global demand for water is increasing daily and according to statistics it will increase by 55% by the year 2050 (WWAP, 2015). The industrial water footprint (IWFP) of a

manufacturing facility is its total water usage for its production processes and the volume of water polluted by the contaminants produced by its industrial processes (Tillotson M. R. et al., 2014). When measuring the industrial water footprint which has three components, green, blue and grey, only the blue and grey water footprints are taken into account (Water Footprint Network, 2016). The results of the studies on water footprint assessment would enable product manufacturers to become more aware about the consequences of excessive usage of water and may also motivate them to produce environmentally friendly products (Wang, Ding, Wu and Yu, 2013). Thus, the aim of this research was to investigate the key enablers of and barriers to water footprint assessment practices followed by the apparel manufacturing industry in Sri Lanka and identify the solutions that will overcome the identified barriers.

2. Literature Review

Water footprint (WFP) is an indicator of the amount of water consumed and polluted by a consumer or a manufacturer of a product and the impact of that water

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DOI: <http://doi.org/10.4038/bhumi.v6i1.33>

usage on water bodies. It is a measure of not only the direct water usage but also the indirect water usage of the consumer or the manufacturer throughout the whole supply chain and considers the amount of water polluted together with the impact that the consumed/polluted water has on water resources (Hoekstra, et al., 2011). A supply chain starts with the raw materials used for the manufacture of a product and it ends with the delivery of the product to the customer (Tummala and Schoenherr, 2011). The international standard for water footprint is ISO 14046:2014 - Environmental Management - Water Footprint - Principles, Requirements and Guidelines. The "Water Footprint Assessment Manual - Setting the Global Standard" published by the Water Footprint Network and based on ISO 14044:2006 Environmental Management - Life Cycle Assessment - Requirements and Guidelines (ISO, 2014) is often referred to by industry practitioners and international researchers engaged in water related work (Chouchane, Hoekstra, Krol and Mekonnen, 2015; Kannan, Osei, Gallego and Saleh, 2017). As Perry (2014) stated, water footprint assessment is carried out with the aim of measuring and analysing the impacts of human activities on water bodies and at motivating individuals and organisations to reduce the adverse effects of those impacts. After considering the viewpoints expressed by different authors as mentioned in the literature, water footprint assessment was defined in this study as an integration of accounting, appropriation and pollution of water resources, assessment of their sustainability and formulation of strategies to reduce their adverse effects. According to Hettige, Mani and Wheeler (2000), the developments taking place in the industrial sector lead to increased environmental pollution. Wang, Ding, Wu and Yu (2013) have also stated that the consumption and pollution of water resources has increased with the development of industries and that the industrial sector contributes to the global water footprint by 4.7%. Water consumption and pollution of the apparel manufacturing industry has a high impact on the global fresh water resources (Goworek, 2011).

According to Kant (2012), an average sized textile mill which manufactures 8000 kg of fabric per day consumes 1.6 million litres of water daily, 16% of which is used for dyeing and 8% for printing. Although during dyeing, only 30-50 litres of water per kg of fabric are used, the whole process of yarn dyeing consumes as much as 60 litres per kg of yarn. According to Kant (2012), dyeing of both yarns and fabrics causes a high percentage of water pollution as it is responsible for 15-20% of the total amount of wastewater generated. More than 8000 chemicals are used in the various processes involved in textile manufacturing and the number of individual dyes manufactured is more than 3600. Water footprints of various products and industries have been recorded from all over the world in the recent past (Ridoutt, et al.,

2009; Perry, 2014). Thus, the measurement of the water consumption of industries and its impacts on the environment are essential to reduce their negative effects on the environment to enable the achievement of water sustainability targets (Jeswani and Azapagic, 2011).

3. Research Methodology

Case study is a type of qualitative research approach used when an in-depth investigation of an issue is required. It can help a researcher to get an understanding of a complex issue or object by extending experience or adding strength to what is already known through previous research (Yin, 2009). On the other hand, survey approach deals with phenomenon and context, but its ability to investigate the context is limited. Since in this research, the current practices followed in the apparel manufacturing industry in respect of water footprint assessments were to be investigated, case study approach was found to be more suitable for the research. Since a high degree of certainty and validity exists in multiple case studies (Yin, 2009), three apparel manufacturing facilities in Sri Lanka were studied in detail to identify the key enablers of and barriers to water footprint assessment in the country. Apparel manufacturing organisations that conduct water footprint assessments were considered as the cases with the water footprint assessment procedure considered as the unit of analysis.

Interviews are the most useful source of data in case studies compared to documents, archival records and direct observations. As Noor (2008) mentioned, data can be collected from interviews using guided conversations in place of structured queries. Hence this research used semi-structured interviews with industry practitioners involved in water footprint assessments in each case study. Table 1 presents the profiles of the cases and the interviewees.

The data collected were analysed using cross case analysis technique as the research involved three case studies. The key enablers of and barriers to the existing practices of water footprint assessments were identified from the case analysis. The next section presents the key findings of the study with reference to the apparel manufacturing industry in Sri Lanka.

4. Key findings and discussion

The key research findings of the cross case analysis are described below under the following two headings:

- (i) Key enablers of water footprint assessment
- (ii) Barriers to water footprint assessment and the solutions to overcome those barriers

Table 1: Profile of cases and the interviewees

Case	Case details			Profiles of the interviewees	
	No of occupants	Sections in the facility	Sources of fresh water	Designation	No. of years of experience
A	1300	Administration, Cutting, Sewing, Finishing and Packing	Well, Tube well and Water bowsers	Manager – Environment Sustain-	07 years
				Senior Executive – Environment	05 years
				Maintenance Manager	08 years
B	1200	Administration, Cutting, Sewing, Washing plant Finishing and Packing	Tube well and City water line	Group Facilities Manager	18 years
				Maintenance Executive	05 years
				Human Resources Manager	07 years
C	600	Administration, Cutting, Sewing, Printing, Finishing and Packing	City water line	Senior Executive – Sustainability	05 years
				Engineering Executive	06 years
				Maintenance Engineer	12 years

4.1 Key enablers of water footprint assessment

The data obtained from case studies were analyzed to identify the enablers of and barriers to water footprint assessments in the apparel manufacturing industry in Sri Lanka. Enablers were first identified. Most organizations are not implementing water footprint assessments fully. Although most of the apparel manufacturing facilities have started implementing water footprint assessments to some extent, they still lack a clear understanding about them. According to the maintenance manager of Case A, water footprint assessment in their organization has been done only to identify the ways of reducing water consumption and pollution. The engineering executive of Case C stated that the water footprint assessment in their organization is supported and directed by their top management to achieve sustainability. The senior executive in charge of environment sustainability in Case A said that they carry out the assessment by referring to the water footprint assessment manual, the standard document referred to everywhere in the world when carrying out water footprint assessments. According to the maintenance engineer of Case C, they had to measure the water footprint of their organization before making an application to green awards and therefore they had to study it before carrying out the assessment. The group facility manager of Case B disclosed that all necessary steps have been taken in their organization to reduce water consumption and pollution. He was confident of making an accurate assessment of the water footprint having already completed some of the stages involved. This enabler was also supported by the manager – environment sustainability of Case A since according to him most of the required measures will already be in place by the time the work on water footprint assessment commences.

Thus, the enablers of water footprint assessment are as follows:

- Fewer number of stages involved
- Top management commitment and support
- Clear direction given to implement the concept
- Availability of standard procedures
- Strategies already adopted to reduce water consumption and pollution
- Positive organizational approach

4.2 Barriers and the solutions to overcome them

The barriers to the existing practices were identified from the case study analysis under the five headings mentioned in the literature, namely (a) General awareness; (b) Setting goals and scope; (c) Water footprint accounting; (d) Water footprint sustainability assessment; and (e) Water footprint response formulation. The solutions proposed by the experts working in the fields of sustainability and water footprint assessments were identified as the strategies that will overcome the identified barriers.

a. General awareness on the concept

Identified barriers – The parties involved in water footprint assessments do not clearly understand the meaning of water footprint. The human resource manager of Case B considered it as the measurement of the total water consumed by a factory. The senior executive – sustainability and the maintenance engineer of Case C considered it as the total amount of water consumed and polluted. The direct and indirect green water footprints were defined mistakenly by the group facilities manager of Case B as the amount of water used for recycling and he was also of the view that there is a need to consider water recycling and rain water harvesting and measuring the quantities of water involved in these processes. According to the

maintenance executive of Case B, the existence of international standards and guidelines that could be followed when carrying out water footprint assessments was not much known and even when they were known there was concern about their applicability to Sri Lanka. Green water footprint was considered as a water sustainability measure adopted in green building. Accordingly, lack of understanding about the exact meaning and the concept of water footprint assessment, its mistaken consideration as the green building concept and wrong assessment processes are the barriers to general awareness.

Proposed solutions - The maintenance executive of Case B wanted a common format with simple definitions for the apparel manufacturing industry to overcome the barriers to the general awareness about the water footprint concept. As stated by manager – environment sustainability of Case A, although a process for water footprint assessment is already in place in his organization, due to lack of understanding of the whole concept, its implementation has become difficult and inaccurate. Thus, if clear definitions applicable to Sri Lanka could be prepared as has been done for the other environmental standards, it will help to provide a clear direction to all organizations to accurately carry out the process. According to the senior executive – sustainability of Case C, seminars, training programs, and workshops which will enhance the awareness about the concept would also help the organizations to reduce their water footprints.

b. Setting goals and scope

Identified barriers - In the absence of awareness about the concept of water footprint assessment, most organizations carry out the assessments wrongly and the supply chain water footprint gets often neglected. According to the manager – environment sustainability of Case A, they do not consider supply chain water footprint as a part of water footprint assessment. The senior executive – sustainability of Case C considered the scope of water footprint assessment to be within the organisation's scope. When there are no guidelines, it will not be known how to establish goals and define the scope. This was confirmed by both the senior executive – environment sustainability and the maintenance manager of Case A as they have not received adequate guidance to establish goals and to define the scope. Thus, the unavailability of guidance for setting goals and scope of the process and the exclusion of supply chain water footprint from the water footprint assessment were identified as barriers to setting goals and scope.

Proposed solutions - Introduction of a national standard for water footprint assessment was one of the key solutions proposed by most of the interviewees. According to the senior executive – environment

sustainability of Case A, most of the issues that arise during water footprint assessments could be sorted out if there is a national standard or a guideline to follow. The group facility manager of Case B was of the view that water footprint assessment needs to be considered under the sustainability goals of an organisation.

c. Water footprint accounting

Identified barriers - A major barrier identified under this heading is the absence of a clear definition for the concept. This was confirmed by the maintenance manager of Case A when he said that they do not have a clear understanding of both direct and indirect water footprints. The direct green water footprint is the amount of water used in green practices. The manager – environment sustainability of Case A considered the difficulties faced in metering effluent water also as a barrier. According to him, the density of particulate in waste water being considerably high compared to that in fresh water, there is a tendency for the conventional meters to get stuck and become inoperative after about 3 months in operation leading to inaccurate meter readings. The replacement of effluent water meters is a critical issue for organisations as according to the maintenance engineer of Case C, it involves high expenditure. It was the view of the group facilities manager of Case B that the unavailability of all inputs required for water footprint assessment is a barrier to the accurate implementation of the concept. The procedure followed in water footprint assessment is difficult according to the executive – engineering of Case C who was of the view that in the absence of little or no guidance on assessment, it is very difficult to conduct the assessment. Accordingly, the absence of a clear definition for the concept, use of incorrect data and the absence of input data required for accounting purposes and recurrent high meter replacement costs were the key barriers identified under this heading.

Proposed solutions - As proposed by the maintenance manager of Case A, the introduction of a national standard for water footprint assessment will solve the issues identified. According to the senior executive – sustainability of Case C, with proper guidance the organizations will not have difficulties in investing money on the process, especially on meter installations.

d. Water footprint sustainability assessment

Identified barriers - Industry practitioners were not much aware on the importance of water footprint sustainability assessments. It appeared that some of the organizations do not include this assessment under water footprint assessments. The manager – environment sustainability of Case a stated that their sustainability assessments are done by the Carbon Consultancy Company in Sri Lanka and as such very little is known about this assessment. This was confirmed when senior

Table 2: Summary of key research findings

Category	Barriers	Solutions
General awareness on the concept	<ul style="list-style-type: none"> Lack of proper understanding about the exact meaning and the concept of water footprint assessment Mistakenly defining the concept as the green building concept Conducting the assessment process wrongly 	<ul style="list-style-type: none"> Introducing a common format with simple definitions Conducting seminars, training programs and workshops to increase the awareness on the concept
Setting goals and scope	<ul style="list-style-type: none"> Non-availability of guidance on setting goals and scope of the process Excluding supply chain water footprint from water footprint assessment 	<ul style="list-style-type: none"> Introducing a national standard for water footprint assessment Including water footprint assessments under the sustainability goals of organisations
Water footprint accounting	<ul style="list-style-type: none"> Absence of a clear definition for the concept Use of incorrect data Recurrent high meter replacement cost 	<ul style="list-style-type: none"> Introducing a national standard for water footprint assessments Providing guidance at national level for water footprint assessments
Water footprint sustainability assessment	<ul style="list-style-type: none"> Lack of awareness on the importance of conducting water footprint sustainability assessments Insufficient guidance available for carrying out sustainability assessments 	<ul style="list-style-type: none"> Providing guidance at national level for water footprint assessments Setting up a national level governing body
Water footprint response formulation	<ul style="list-style-type: none"> Financial barriers to the implementation of sustainable measures Negative responses received from the staff to sustainable approaches 	<ul style="list-style-type: none"> Making available guidelines emphasising the long term financial and other benefits of water footprint assessment Developing a sustainability culture within the organisations

executive – environment sustainability of Case C stated that guidance available for carrying out sustainability assessments was insufficient. Thus, lack of awareness on the importance of conducting water footprint sustainability assessments and the insufficient guidance available for carrying out sustainability assessments were identified under this heading as the key barriers to water footprint sustainability assessment.

Proposed solutions - Most of the interviewees were of the view that there should be guidance at national level for water footprint assessments. They were also of the view that if there is a national level governing body, it would help the organizations to conduct all stages of the assessment accurately.

e. Water footprint response formulation

Identified barriers – The practitioners of water footprint assessments have experienced financial barriers. According to the senior executive – environment sustainability of Case A, financial barriers are caused by the longer payback periods of sustainability assessments. The group facilities manager of Case B stated that they were unable to implement all stages of water footprint assessment at once because of financial barriers. As

mentioned by the maintenance manager of Case A, some of the staff were reluctant to change and their negative responses made it impossible to implement sustainable measures fully. Accordingly, financial barriers to the implementation of sustainable measures and the negative responses received from staff with regard to sustainable approaches were identified as the barriers to the exiting practices of water footprint assessment.

Proposed solutions - As proposed by the interviewees, the guidelines made available should indicate the long term financial and other benefits of water footprint assessment to encourage organizations to implement this concept. Sustainability culture should be developed within the organizations through training programs. Table 2 summarizes the key research findings of the case study data analysis. Based on the empirical findings, a framework as illustrated in Figure 1 was developed.

5. Conclusions and recommendations

This study recommends solutions to overcome the barriers encountered in water foot print assessment in the apparel manufacturing facilities in Sri Lanka. The framework developed provides a basis to evaluate and

Figure 1: Framework Developed

improve the water footprint assessment procedures of organizations. As empirical findings revealed, there has to be a national standard for water footprint assessment giving simple definitions and descriptive and clear procedures to overcome most of the barriers faced in executing the existing practices. The solutions provided in the framework under general awareness about the concept, setting goals and scope, water footprint accounting, water footprint sustainability assessment and water footprint response formulation would enable proper implementation of water footprint assessment in the apparel manufacturing industry in Sri Lanka.

The conceptual framework developed consists of issues related to the current practices of water footprint assessment and general awareness about water footprint which were identified from the three case studies. Furthermore, it will provide suggestions to overcome the identified issues, to reach the ultimate goal of accurate water footprint assessment in apparel manufacturing industrial facilities in Sri Lanka.

6. References

- Chouchane, H., Hoekstra, A. Y., Krol, M. S. and Mekonnen, M. M. (2015). The water footprint of Tunisia from an economic perspective. *Ecological Indicators*, 52, 311-319. doi:10.1016/j.ecolind.2014.12.015
- Cohen, D. (2006): *Qualitative Research Guidelines Project. Semi-structured interviews*. New Jersey: Robert Wood Johnson Foundation.
- Diop, S., M'mayi, P. and Lisbjerg, D. (2002). *Vital water graphics: An overview of the state of the world's fresh and marine waters*. Nairobi, Kenya: United Nations Environment Programme.
- Goworek, H. (2011). Social and environmental sustainability in the clothing industry: a case study of a fair trade retailer. *Social Responsibility Journal*, 7(1), 74-86. doi:10.1108/17471111111114558
- Hettige, H., Mani, M., and Wheeler, D. (2000). Industrial pollution in economic development: the environmental Kuznets curve revisited. *Journal of Development Economics*, 62(2), 445-476. doi:10.1016/s0304-3878(00)00092-4
- International Organisation for Standardization. (2014). *Environmental management: Water footprint - principles, requirements and guidelines*. Geneva.
- Jeswani, H. K., and Azapagic, A. (2011). Water footprint: methodologies and a case study for assessing the impacts of water use. *Journal of Cleaner Production*, 19(12), 1288-1299. doi:10.1016/j.jclepro.2011.04.003
- Kannan, N., Osei, E., Gallego, O., and Saleh, A. (2017). Estimation of green water footprint of animal feed for beef cattle production in Southern Great Plains. *Water Resources and Industry*, 17, 11-18. doi:10.1016/j.wri.2016.12.002
- Kant, R. (2012). Textile dyeing industry an environmental hazard. *Natural Science*, 04(01), 22-26. doi:10.4236/ns.2012.41004
- Noor, K.B.M. (2008). Case study: a strategic research methodology. *American Journal of Applied Science*, 2008 (5): 1602-1604.
- Perry, C. (2014). Water footprints: Path to enlightenment, or false trail? *Agricultural Water Management*, 134, 119-125. doi:10.1016/j.agwat.2013.12.004
- Pfister, S., Boulay, A., Berger, M., Hadjikakou, M., Motoshita, M., Hess, T. and Henderson, A. (2017). Understanding the LCA and ISO water footprint: A response to Hoekstra "critique on the water-scarcity weighted water footprint in LCA". *Ecological Indicators*, 72, 352-359. doi:10.1016/j.ecolind.2016.07.051
- Ridoutt, B. G. and Pfister, S. (2010). A revised approach to water footprinting to make transparent the impacts of consumption and production on global freshwater scarcity. *Global Environmental Change*, 20(1), 113-120. doi:10.1016/j.gloenvcha.2009.08.003
- Sodhi, S.M. and Yatskovskaya, E. (2014). Developing a sustainability index for companies' efforts on responsible use of water. *International Journal of Productivity and Performance Management*, 63(7), 800-821. doi:10.1108/ijppm-03-2013-0053
- Tillotson, M. R., Liu, J., Guan, D., Wu, P., Zhao, X., Zhang, G. and Pahlow, M. (2014). Water Footprint Symposium: where next for water footprint and water assessment methodology? *The International Journal of Life Cycle Assessment*, 19(8), 1561-1565. doi:10.1007/s11367-014-0770-x
- Tummala, R. and Schoenherr, T. (2011). Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP). *Supply Chain Management: An International Journal*, 16(6), 474-483. doi:10.1108/13598541111171165
- Wang, L., Ding, X., Wu, X. and Yu, J. (2013). Textile industrial water footprint: methodology and study. *Journal of Scientific and Industrial Research*, 72, 710-715.
- Water Footprint Network - WFN. (2016). Aims and history. Retrieved from <http://waterfootprint.org/en/about-us/aims-history> (Accessed: 2016, May 16).
- World Water Assessment Programme (United Nations) UN-Water. (2014). *The United Nations world water development report 2014*. Paris: United Nations Educational, Scientific and Cultural Organisation.
- Yin, R. K. (2009). *Case Study Research (4th ed.)*. London: SAGE Inc.